

Marine Mammal Monitoring and Mitigation Plan

Exploration Drilling of Selected Lease Areas in The Alaskan Chukchi Sea



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ACRONYMS

°C	degrees Celsius
°T	degrees True North
μPa	microPascals(s)
4MP	Marine Mammal Monitoring and Mitigation Plan
AMAR	Autonomous Multi-channel Acoustic Recorder(s)
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
cm	centimeter(s)
cm ³	cubic centimeter(s)
dB	decibel
<i>Discoverer</i>	<i>M/V Noble Discoverer</i>
DNV	Det Norske Veritas
DP	Dynamic Positioning
ft.	feet
GPS	Global Positioning System
HSWUA	Hana Shoal Walrus Use Area
Hz	Hertz
in ³	cubic inches
JASCO	JASCO Applied Sciences
kHz	kilohertz
km	kilometer(s)
LBCHU	Ledyard Bay Critical Habitat Unit
Leq	sound energy equivalent level
m	meters
mi	mile(s)
MLC	Mudline Cellar
MMPA	Marine Mammal Protection Act
MONM	Marine Operations Noise Model
NMFS	National Marine Fisheries Service
NSB	North Slope Borough
NVD	Night-vision Device(s)
OBH	Ocean Bottom Hydrophone
<i>Polar Pioneer</i>	<i>Transocean Polar Pioneer</i>
psi	pounds per square inch
PSO	Protected Species Observer(s)
rms	root-mean-square
Shell	Shell Gulf of Mexico Inc.
UAS	Unmanned Aerial System
USFWS	United States Fish and Wildlife Service
ZVSP	Zero-offset Vertical Seismic Profile

INTRODUCTION

Shell Gulf of Mexico Inc. (Shell) will conduct a Marine Mammal Monitoring and Mitigation Plan (4MP) for exploration drilling activities in the Chukchi Sea during the drilling season. The 4MP developed for Shell's exploration drilling program supports protection of the marine mammal resources, fulfills reporting obligations to the Bureau of Ocean Energy Management (BOEM), Bureau of Safety and Environmental Enforcement (BSEE), the National Marine Fisheries Service (NMFS), the United States Fish and Wildlife Service (USFWS); and establishes a means for gathering additional data on marine mammals for future operational planning.

Shell plans to conduct exploration drilling within existing leases in the Chukchi Sea. Drilling will be conducted from the self-propelled drillship *M/V Noble Discoverer* (*Discoverer*) owned and operated by Noble Corporation and the towed semi-submersible *Polar Pioneer* owned by Transocean. The *Discoverer* is ice-class rated and capable of performing drilling operations in offshore Alaska. Similarly, the *Polar Pioneer* is specially designed and classed by Det Norske Veritas (DNV) as a 1A1 column stabilized drilling unit capable of operating in offshore Alaska. In addition to the drilling units, various support vessels will be required. The support vessels will include tugs and barges, ice management vessels, anchor handlers, and oil spill response vessels.

At or near the end of well construction, a Zero-offset Vertical Seismic Profile (ZVSP) survey will be conducted for each well. During the ZVSP surveys, an airgun array is deployed adjacent to the drilling units, while receivers are placed in the wellbore. The sound source (airgun array) is fired, then the reflected sonic waves are recorded by receivers (geophones) located in the wellbore. The surveys may last 10-14 hours each; as the receivers are moved through the length of the wellbore, the airguns may be fired 5-7 times after each movement. The purpose of the ZVSP survey is to gather geophysical information at various depths, which can then be used to tie in or ground truth geophysical information from the previous seismic surveys with geological data collected within the wellbore.

Shell's 4MP is a combination of active monitoring in the area of operations and the implementation of mitigation measures designed to minimize project impacts to marine resources. Monitoring will provide information on the numbers of marine mammals potentially affected by exploration activities, in addition to facilitating real time mitigation to prevent injury of marine mammals by industrial sounds or activities. These goals will be accomplished by conducting vessel based visual monitoring, aerial photographic monitoring, and acoustic monitoring programs to document the potential reactions of marine mammals in the area to the various sounds and activities, in addition to characterizing the sounds produced by drilling activities, support vessels, and ZVSP surveys.

A minimally-manned aerial photographic survey around the offshore drilling operations, opportunistic aerial photographic surveys to monitor marine mammals in coastal and nearshore areas of the Chukchi Sea, and recordings of ambient sound levels and vocalizations of marine mammals from bottom-founded hydrophones placed in large arrays across the Chukchi Sea will be used to interpret potential reactions of marine mammals to the offshore exploration drilling operations and in subsistence use areas closer to shore. Acoustic measurements will be made to establish exclusion zones for real time mitigation around ZVSP surveys and to verify pre-season estimates of the sound footprints and disturbance zones for exploration drilling activities. The exploration drilling activities that will be characterized include movement of the drilling units, drilling sounds, resupply and discharge monitoring support vessels using dynamic positioning (DP) while in direct support of the moored drilling units, mudline cellar (MLC) construction, anchor setting and connecting of the drilling units, and ice management activities; as well as the sound signatures of contracted Shell vessels that have not previously been recorded in the activity area. A detailed report of the sound source analyses will be issued to the NMFS as part of the 90-day report following the end of the exploration drilling season. Shell will continue to measure the sound propagation of exploration drilling activities throughout the exploration drilling season.

VESSEL BASED MARINE MAMMAL MONITORING PROGRAM

Shell's vessel based 4MP is designed to meet the requirements of the Marine Mammal Protection Act (MMPA) non-lethal, incidental take authorizations for marine mammals (MMPA authorizations) which Shell has requested from the NMFS and the USFWS. The 4MP also addresses other stipulated agreements between Shell and additional agencies or groups. The objectives of the program are to ensure that disturbance to marine mammals and subsistence hunts is minimized, that effects on marine mammals are documented, and that data are collected on the occurrence and distribution of marine mammals in the project area.

The 4MP will be implemented by a team of experienced protected species observers (PSOs). The PSOs will be experienced biologists and Alaska Native personnel trained as field observers. PSOs will be stationed on both drilling units, ice management vessels, anchor handlers and other drilling support vessels engaged in transit to and between drill sites to monitor for marine mammals. The duties of the PSOs will include watching for and identifying marine mammals, recording their numbers, recording distances and reactions of marine mammals to exploration drilling activities, initiating mitigation measures when appropriate, and reporting results of the vessel based monitoring program, which will include the estimation of the number of marine mammal "exposures" as defined by the NMFS and stipulated in its MMPA authorization for Shell.

Exploration activity dates and areas will depend upon ice and weather conditions. The *Discoverer*, the *Polar Pioneer* and support vessels will transit through the Bering Strait into the Chukchi Sea on or about July 1¹ and will arrive on location at the Burger Prospect to commence drilling activities as soon as ice, weather, and other conditions safely allow. Vessel based monitoring for marine mammals will be done throughout Shell's exploration drilling activities in compliance with the MMPA authorizations issued by the NMFS and the USFWS.

The vessel based work will provide:

- the basis for real-time mitigation, if necessary, as required by the various permits that Shell receives;
- information needed to estimate the number of "exposures" of marine mammals to sound levels that may result in harassment, which must be reported to NMFS and USFWS;
- data on the occurrence, distribution, and activities of marine mammals in the areas where drilling activity is conducted;
- information to compare the distances, distributions, behavior, and movements of marine mammals relative to the drilling unit during times with and without drilling activity occurring;
- a communication channel to coastal communities including whalers; and
- employment and capacity building for local residents, with one objective being to develop a larger pool of experienced Alaska Native PSOs.

The 4MP will be operated and administered consistent with monitoring programs conducted during past exploration drilling activities, seismic and shallow hazards surveys, or alternative requirements stipulated in permits issued to Shell. Agreements between Shell and other agencies will also be fully incorporated. PSOs will be provided training through a program approved by the NMFS and Shell.

¹ As noted in the EP Revision 2, Shell may request permission to transit through the Bering Strait prior to July 1, 2015.

MITIGATION MEASURES DURING EXPLORATION DRILLING ACTIVITIES

Shell's planned exploration drilling activities incorporate design features and operational procedures aimed at minimizing potential impacts on marine mammals and subsistence hunts. The design and operational procedures of the mitigation measures have been described in the MMPA authorization requests, to which this 4MP is appended. Some of the mitigation design features include:

- timing and locating drilling support activities to avoid interference with the annual subsistence hunt by Chukchi villages;
- conducting pre-season acoustic modeling to establish the appropriate exclusion and disturbance zones;
- vessel based monitoring to implement appropriate mitigation if necessary, and to determine the effects of drilling activities on marine mammals;
- acoustic monitoring of drilling and vessel sounds and marine mammal vocalizations; and
- aerial surveys with photographic equipment over operations and in coastal and nearshore waters to help determine the effects of project activities on marine mammals; and seismic activity mitigation measures during acquisition of the ZVSP surveys.

The potential disturbance of marine mammals during drilling activities will be mitigated through the implementation of several vessel based mitigation measures as necessary.

Exclusion and Disturbance Zones

Under current NMFS guidelines (e.g., NMFS 2000), "safety radii" or "exclusion zones" for marine mammals around airgun arrays and other impulsive industrial sound sources are customarily defined as the distances within which received levels are ≥ 180 decibel (dB) re 1 microPascal (μ Pa) root-mean-square (rms) for cetaceans and ≥ 190 dB re 1 μ Pa rms for pinnipeds. The ≥ 180 and ≥ 190 dB rms guidelines are also employed by USFWS for Pacific walrus and polar bear. These safety criteria are based on a cautionary assumption that sound energy at lower received levels will not harm these animals or impair their hearing abilities, but that higher received levels might have some such effects. Disturbance or behavioral effects to marine mammals from underwater sound may occur after exposure to sound at distances greater than the exclusion zone (Richardson et al. 1995). The NMFS assumes that marine mammals exposed to pulsed airgun sounds with received levels ≥ 160 dB re 1 μ Pa rms or continuous sounds from vessel activities with received levels ≥ 120 dB re 1 μ Pa rms have the potential to be disturbed. As a result, these sound level thresholds are currently used by NMFS to define acoustic disturbance criteria.

Exploration Drilling Activities

The areas exposed to sounds produced by the drilling units *Discoverer* and *Polar Pioneer* were determined by measurements from drilling in 2012 or were modeled by JASCO Applied Sciences. The 2012 measurement of the distance to the 120 dB rms threshold for normal drilling activity by the *Discoverer* was 0.93 miles (mi) (1.5 kilometers [km]) while the distance of the ≥ 120 dB rms radius during MLC construction was 5.1 mi (8.2 km).

Measured sound levels for the *Polar Pioneer* were not available. Its sound footprint was estimated with JASCO's Marine Operations Noise Model (MONM) using an average source level derived from a number of reported acoustic measurements of comparable semi-submersible drill units, including the Ocean Bounty (Gales, 1982), SEDCO 708 (Greene, 1986), and Ocean General (McCauley, 1998). The model yielded a propagation range of 0.22 mi (0.35 km) for rms sound pressure levels of 120 dB for the *Polar Pioneer* while drilling at the Burger Prospect.

In addition to drilling and MLC construction, numerous activities in support of exploration drilling produce continuous sounds above 120 dB rms. These activities in direct support of the moored drilling units include ice management, anchor handling, and supply/discharge sampling vessels using DP thrusters. Detailed sound characterizations for each of these activities are presented in the 2012 Comprehensive Report (JASCO and Greeneridge 2014)

The source levels for exploration drilling and related support activities are not high enough to cause temporary reduction in hearing sensitivity or permanent hearing damage to marine mammals. Consequently, mitigation as described for seismic activities including ramp ups, power downs, and shut downs should not be necessary for exploration drilling activities. However, Shell plans to use PSOs onboard the drilling units, ice management, and anchor handling vessels to monitor marine mammals and their responses to industry activities, in addition to initiating mitigation measures should in-field measurements of the activities indicate conditions that may present a threat to the health and well-being of marine mammals.

ZVSP Surveys

Two sound sources have been proposed by Shell for the ZVSP surveys. The first is a small airgun array that consists of three 150 in³ (2,458 cubic centimeters [cm³]) airguns for a total volume of 450 in³ (7,374 cm³). The second ZVSP sound source consists of two 250 in³ (4,097 cm³) airguns with a total volume of 500 in³ (8,194 cm³). Sound footprints for each of the two proposed ZVSP airgun array configurations were estimated using JASCO Applied Sciences MONM. The model results were maximized over all water depths between 9.9 and 23 feet (ft.) (3 and 7 meters [m]) to yield sound level isopleths as a function of range and direction from the source. The 450 in³ airgun array at a source depth of 23 ft. (7 m) yielded the maximum ranges to the ≥ 190 , ≥ 180 , and ≥ 160 dB rms isopleths.

There are two reasons that the radii for the 450 in³ airgun array is larger than the 500 in³ array; first, the sound energy does not scale linearly with the airgun volume; rather it is proportional to the cube root of the volume. Thus, the total sound energy from three airguns is larger than the total energy from two airguns, even though the total volume is smaller. Second, larger volume airguns emit more low-frequency sound energy than smaller volume airguns, and low-frequency airgun sound energy is strongly attenuated by interaction with the surface reflection. Thus, the sound energy for the larger-volume array experiences more reduction and results in shorter sound threshold radii.

The estimated 95th percentile distances to the following thresholds for the 450 in³ airgun array were: ≥ 190 dB = 558 ft. (170 m), ≥ 180 dB = 3,018 ft. (920 m), and ≥ 160 dB = 26,148 ft. (7,970 m). These distances were multiplied by 1.5 as a conservative measure, and the resulting radii are shown in Table 1. PSOs on the drilling units will initially use the radii in Table 1 for monitoring and mitigation purposes during ZVSP surveys. An acoustics contractor will perform direct measurements of the received levels of underwater sound versus distance and direction from the ZVSP array using calibrated hydrophones. The acoustic data will be analyzed as quickly as reasonably practicable and used to verify (and if necessary adjust) the threshold radii distances during later ZVSP surveys. The mitigation measures to be implemented will include pre-ramp up watches, ramp ups, power downs and shut downs as described below.

TABLE 1. ESTIMATED DISTANCES OF THE ≥ 190 , 180, AND 160, dB RMS ISOPLETHS TO BE USED FOR MITIGATION PURPOSES DURING ZVSP SURVEYS UNTIL SSV RESULTS ARE AVAILABLE.

Threshold levels in dB re 1 μ Pa rms	Estimated Distance (m)
≥ 190	255
≥ 180	1,380
≥ 160	11,960

Ramp Ups

A ramp up of an airgun array provides a gradual increase in sound levels, and involves a step-wise increase in the number and total volume of airguns firing until the full volume is achieved. The purpose of a ramp up (or “soft start”) is to “warn” cetaceans and pinnipeds in the vicinity of the airguns and to provide time for them to leave the area, thus avoiding any potential injury or impairment of their hearing abilities.

During the proposed ZVSP surveys, the operator will ramp up the airgun arrays slowly. Full ramp ups (i.e., from a cold start when no airguns have been firing) will begin by firing a single airgun in the array. A full ramp up will not begin until there has been observation of the exclusion zone by PSOs for a minimum of 30 minutes to ensure that no marine mammals are present. The entire exclusion zone must be visible during the 30 minutes leading into to a full ramp up. If the entire exclusion zone is not visible, a ramp up from a cold start cannot begin. If a marine mammal is sighted within the exclusion zone during the 30 minutes prior to ramp up, ramp up will be delayed until the marine mammal is sighted outside of the exclusion zone or is not sighted for at least 15-30 minutes: 15 minutes for small odontocetes and pinnipeds, or 30 minutes for baleen whales and large odontocetes.

Power Downs and Shut Downs

A power down is the immediate reduction in the number of operating energy sources from all firing to some smaller number. A shut down is the immediate cessation of firing of all energy sources. The arrays will be immediately powered down whenever a marine mammal is sighted approaching close to or within the applicable exclusion zone of the full arrays, but is outside the applicable exclusion zone of the single source. If a marine mammal is sighted within the applicable exclusion zone of the single energy source, the entire array will be shut down (i.e., no sources firing).

Protected Species Observers

Vessel based monitoring for marine mammals will be done by trained PSOs on both drilling units, ice management and anchor handler vessels throughout the exploration drilling activities to comply with mitigations contained in Shell’s MMPA authorizations. The observers will monitor the occurrence and behavior of marine mammals near the drilling units, ice management and anchor handling vessels, during all daylight periods during the exploration drilling operation, and during most periods when exploration drilling is not being conducted. PSO duties will include watching for and identifying marine mammals; recording their numbers, distances, and reactions to the exploration drilling activities; and documenting exposures to sound levels that may constitute harassment as defined by NMFS.

Number of Observers

A sufficient number of PSOs will be onboard to meet the following criteria

- 100 percent monitoring coverage during all periods of exploration drilling operations in daylight;
- Maximum of four consecutive hours on watch per PSO; and
- Maximum of approximately 12 hours on watch per day per PSO

PSO teams will consist of trained Alaska Natives and field biologist observers. An experienced field crew leader will be on every PSO team aboard the drilling units, ice management and anchor handling vessels, and other support vessels during the exploration drilling program. The total number of PSOs aboard may decrease later in the season as the duration of daylight decreases assuming the NMFS does not require continuous nighttime monitoring. PSOs will help ensure that the vessel communicates with the Communications and Call Centers (Com Centers) in Native villages along the Chukchi Sea coast.

Crew Rotation

Shell anticipates that there will be provisions for crew rotation at least every three to six weeks to avoid observer fatigue. During crew rotations detailed notes will be provided to the incoming crew leader. Other communications such as email, fax, and/or phone communication between the current and oncoming crew leaders during each rotation will also occur when necessary. In the event of an unexpected crew change Shell will facilitate such communications to ensure monitoring consistency among shifts.

Observer Qualifications and Training

Crew leaders serving as PSOs will have experience from one or more projects with operators in Alaska or the Canadian Beaufort.

Biologist-observers will have previous PSO experience, and crew leaders will be highly experienced with previous vessel based marine mammal monitoring projects. Resumes for those individuals will be provided to the NMFS for approval. All PSOs will be trained and familiar with the marine mammals of the area. A PSO handbook, adapted for the specifics of the planned Shell drilling program will be prepared and distributed beforehand to all PSOs.

All observers will also complete a training session on marine mammal monitoring, to be conducted shortly before the anticipated start of the drilling season. The training sessions will be conducted by marine mammalogists with extensive crew leader experience from previous vessel based monitoring programs in the Arctic.

Primary objectives of the training include:

- review of the 4MP for this project, including any amendments adopted, or specified by the NMFS the USFWS, the BOEM, the BSEE, or other agreements in which Shell may elect to participate;
- review of marine mammal sighting, identification, (photographs and videos) and distance estimation methods, including any amendments specified by the NMFS or the USFWS in the MMPA authorizations issued to Shell;
- review operation of specialized equipment (e.g., reticle binoculars, big eye binoculars, night vision devices, Global Positioning System (GPS); and
- review of data recording and data entry systems, including procedures for recording data on mammal sightings, exploration drilling and monitoring activities, environmental conditions, and entry error control. These procedures will be implemented through use of a customized computer databases and laptop computers.

PSO Handbook

A PSO Handbook will be prepared for Shell's monitoring program. The Handbook will contain maps, illustrations, and photographs as well as copies of important documents and descriptive text and are intended to provide guidance and reference information to trained individuals who will participate as PSOs. The following topics will be covered in the PSO Handbook:

- summary overview descriptions of the project, marine mammals and underwater sound energy, the 4MP (vessel-based, aerial, acoustic measurements, special studies), the NMFS and USFWS MMPA authorizations and other regulations/permits/agencies,;
- monitoring and mitigation objectives and procedures, including initial exclusion and disturbance zones;
- responsibilities of staff and crew regarding the 4MP;

- instructions for staff and crew regarding the 4MP;
- data recording procedures: codes and coding instructions, common coding mistakes, electronic database; navigational, marine physical, and drilling data recording, field data sheet;
- use of specialized field equipment (e.g., reticle binoculars, Big-eye binoculars, Night Vision Devices [NVD], laser rangefinders);
- reticle binocular distance scale;
- table of wind speed, Beaufort wind force, and sea state codes;
- data storage and backup procedures;
- list of species that might be encountered: identification, natural history;
- safety precautions while onboard;
- crew and/or personnel discord; conflict resolution among PSOs and crew;
- drug and alcohol policy and testing;
- scheduling of cruises and watches;
- communications;
- list of field gear provided;
- suggested list of personal items to pack;
- suggested literature, or literature cited;
- field reporting requirements and procedures;
- copies of the MMPA authorizations will be made available; and
- areas where vessels cannot operate such as the Ledyard Bay Critical Habitat Unit (LBCHU) and Hana Shoal Walrus Use Area (HSWUA).

MONITORING METHODOLOGY

Each of the two drilling units and primary ice management vessels will be staffed with five PSOs. Each of the two anchor handling vessels will be staffed with four PSOs. All of the remaining ocean-going support vessels will be staffed with at least a single PSO and up to three observers in all cases where accommodations aboard the vessel are sufficient to support this level of PSO staffing. At least two PSOs will be on watch aboard the drilling units and ice management vessels during all daylight periods when active drilling and ice management are occurring. Effort periods with two PSOs on watch aboard anchor handling vessels will be maximized during all daylight periods while active anchor handling operations are ongoing. At least one PSO will be on watch during all active drilling, ice management, and anchor handling activities that occur during darkness. PSO watch effort aboard support vessels will be scheduled to maximize monitoring during active vessel operations in support of primary vessel activities, including transit periods.

The observer(s) will watch for marine mammals from the best available vantage point on the drilling units and support vessels. Ideally this vantage point is an elevated stable platform from which the PSO has an unobstructed 360° view of the water. The observer(s) will scan systematically with the naked eye and 7 × 50 reticle binoculars, supplemented with Big-eye binoculars and night-vision equipment when needed (see below). Personnel on the bridge will assist the PSOs in watching for pinnipeds and cetaceans. New or inexperienced PSOs will be paired with an experienced PSO or experienced field biologist so that the quality of marine mammal observations and data recording is kept consistent.

Information to be recorded by PSOs will include the same types of information that were recorded during previous monitoring projects (e.g., Moulton and Lawson 2002; Reiser et al. 2010, 2011; Bisson et al.

2013). When a mammal sighting is made, the following information about the sighting will be carefully and accurately recorded:

- species, group size, age/size/sex categories (if determinable), physical description of features that were observed or determined not to be present in the case of unknown or unidentified animals;
- behavior when first sighted and after initial sighting;
- heading (if consistent), bearing and distance from observer;
- apparent reaction to activities (e.g., none, avoidance, approach, paralleling, etc.), closest point of approach, and behavioral pace;
- time, location, speed, and activity of the vessel, sea state, ice cover, visibility, and sun glare, on support vessels the distance and bearing to the drilling unit will also be recorded; and
- the position of other vessel(s) in the vicinity of the observer location.

The vessel's position, speed, water depth, sea state, ice cover, visibility, and sun glare will also be recorded at the start and end of each observation watch, every 30 minutes during a watch, and whenever there is a change in any of those variables.

Distances to nearby marine mammals will be estimated with binoculars (Fujinon 7×50 binoculars) containing a reticle to measure the vertical angle of the line of sight to the animal relative to the horizon.

An electronic database will be used to record and collate data obtained from visual observations during the vessel-based study. The PSOs will enter the data into the custom data entry program installed on field laptops. The data entry program automates the data entry process and reduces data entry errors and maximizes PSO time spent looking at the water. PSOs also have voice recorders available to them. This is another tool that will allow PSOs to maximize time spent focused on the water.

PSO's are instructed to identify animals as unknown when appropriate rather than strive to identify an animal when there is significant uncertainty. Shell also will ask that they provide any sightings cues they used and any distinguishable features of the animal even if they are not able to identify the animal and record it as unidentified. Emphasis is also placed on recording what was not seen, such as dorsal features.

Monitoring At Night and In Poor Visibility

Night-vision equipment "Generation 3" binocular image intensifiers or equivalent units will be available for use when needed. However, past experience with NVDs in the Beaufort Sea and elsewhere indicates that NVDs are not nearly as effective as visual observation during daylight hours (e.g., Harris et al. 1997, 1998; Moulton and Lawson 2002; Hartin et al, 2011).

Specialized Field Equipment

Shell will provide or arrange for the following specialized field equipment for use by the onboard PSOs: reticle binoculars, Big-eye binoculars, GPS unit, laptop computers, night vision binoculars, and possibly digital still and digital video cameras. Big eye binoculars will be mounted and used on key monitoring vessels including the drilling units, ice management vessels and the anchor handler.

Field Data-Recording, Verification, Handling, and Security

The observers on the drilling units and support vessels will record their observations directly into computers using a custom software package. The accuracy of the data entry will be verified in the field by computerized validity checks as the data are entered, and by subsequent manual checking. These procedures will allow initial summaries of data to be prepared during and shortly after the field season, and will facilitate transfer of the data to statistical, graphical or other programs for further processing.

Quality control of the data will be facilitated by (1) the start-of-season training session, (2) subsequent supervision by the onboard field crew leader, and (3) ongoing data checks during the field season.

The data will be sent off of the vessel to Anchorage on a daily basis and backed up regularly onto storage devices on the vessel, and stored at separate locations on the vessel. If practicable, hand-written data sheets will be photocopied daily during the field season. Data will be secured further by having data sheets and backup data devices carried back to the Anchorage office during crew rotations.

In addition to routine PSO duties, observers will be encouraged to record comments about their observations into the “comment” field in the database. Copies of these records will be available to the observers for reference if they wish to prepare a statement about their observations. If prepared, this statement would be included in the 90-day and comprehensive reports documenting the monitoring work.

PSOs will be able to plot sightings in near real-time for their vessel. Significant sightings from key vessels including drilling units, ice management, and anchor handlers will be relayed between platforms to keep observers aware of animals that may be in or near the area but may not be visible to the observer at any one time. Emphasis will be placed on relaying sightings with the greatest potential to involve mitigation or reconsideration of a vessel's course (e.g., large group of bowheads, walruses on ice).

Observer training will emphasize the use of “comments” for sightings that may be considered unique or not fully captured by standard data codes. In addition to the standard marine mammal sightings forms, a specialized form was developed for recording traditional knowledge and natural history observations. PSOs will be encouraged to use this form to capture observations related to any aspect of the arctic environment and the marine mammals found within it. Examples might include relationships between ice and marine mammal sightings, marine mammal behaviors, comparisons of observations among different years/seasons, etc. Voice recorders will also be available for observers to use during periods when large numbers of animals may be present and it is difficult to capture all of the sightings on written or digital forms. These recorders can also be used to capture traditional knowledge and natural history observations should individuals feel more comfortable using the recorders rather than writing down their comments. Copies of these records will be available to all observers for reference if they wish to prepare a statement about their observations for reporting purposes. If prepared, this statement would be included in the 90-day and final reports documenting the monitoring work.

Field Reports

Throughout the exploration drilling program, the biologists will prepare a report each day or at such other interval as required summarizing the recent results of the monitoring program. The reports will summarize the species and numbers of marine mammals sighted. These reports will be provided to agencies as required.

REPORTING

The results of the vessel-based monitoring, including estimates of exposure to key sound levels, will be presented in the 90-day and final technical report(s). Reporting will address the requirements established by the NMFS and USFWS MMPA authorizations (if so stipulated).

The technical report(s) will include:

- summaries of monitoring effort: total hours, total distances, and distribution of marine mammals through study period for sea state, and other factors affecting visibility and detectability of marine mammals;
- analyses of the effects of various factors influencing detectability of marine mammals: sea state, number of observers, and fog/glare;

- species composition, occurrence, and distribution of marine mammal sightings including date, water depth, numbers, age/size/gender categories (when discernible), group sizes, and ice cover; and
- analyses of the effects of exploration drilling operations:
 - sighting rates of marine mammals during periods with and without exploration drilling activities (and other variables that could affect detectability);
 - initial sighting distances versus drilling state;
 - closest point of approach versus drilling state;
 - observed behaviors and types of movements versus drilling state;
 - numbers of sightings/individuals seen versus drilling state;
 - distribution around the drilling units and support vessels versus drilling state; and
 - estimates of “take by harassment”.

Data will be visualized by plotting sightings relative to the position of the exploratory drilling activities. Shell will also overlay the sightings data with acoustic data that indicates the sound levels associated with the exploration drilling activity and with maps of call locations determined by the seafloor recorders. Additionally, sightings data will be incorporated into animations of the call locations around the exploration drilling activity. Seafloor recorders used in the Chukchi Sea do not have the ability to localize calls.

Shell will consider requests for data collected during the marine mammal monitoring only after the data have been put through a quality control/quality assurance program. Such requests may include incorporating the data with data from other companies and/or integrating the raw data with data from other marine mammal studies.

ACOUSTIC MONITORING PLAN

EXPLORATION DRILLING, ZVSP AND VESSEL SOUND MEASUREMENTS

Objectives

Exploration drilling sounds are expected to vary significantly with time due to variations in the level of operations and the different types of equipment used at different times onboard the drilling units. The goals of the measurements are:

- to quantify the absolute sound levels produced by exploration drilling and to monitor their variations with time, distance and direction from the drilling unit;
- to measure the sound levels produced by vessels while operating in direct support of exploration drilling operations. These vessels will include crew change vessels, tugs, ice-management vessels, and spill response vessels not measured in 2012; and
- to measure the sound levels produced by an end-of-hole ZVSP survey using a stationary sound source.

Exploration Drilling Sound Characterization

Sound characterization and measurements of all exploration drilling activities will be performed using six Autonomous Multi-channel Acoustic Recorders (AMAR) (Figures 1 and 2) deployed on the seabed along the same radial at distances of 0.31, 0.62, 1.2, 2.5, 5 and 10 mi (0.5, 1, 2, 4, 8 and 16 km) from each drilling unit. All six recording stations will sample at least at 32 Kilohertz (kHz), providing calibrated acoustic measurements in the 5 Hertz (Hz) to 16 kHz frequency band. The logarithmic spacing of the

recorders is designed to sample the attenuation of drilling unit sounds with distance. The autonomous recorders will sample through completion of the first well, to provide a detailed record of sounds emitted from all activities. These recorders will be retrieved and their data analyzed and reported in the project's 90-day report.

FIGURE 1 GEOMETRY OF THE FIVE AMARs WILL SAMPLE SOUND PRODUCED BY EXPLORATION DRILLING OPERATIONS FOR THE DRILLING UNITS *DISCOVERER* AND *POLAR PIONEER*

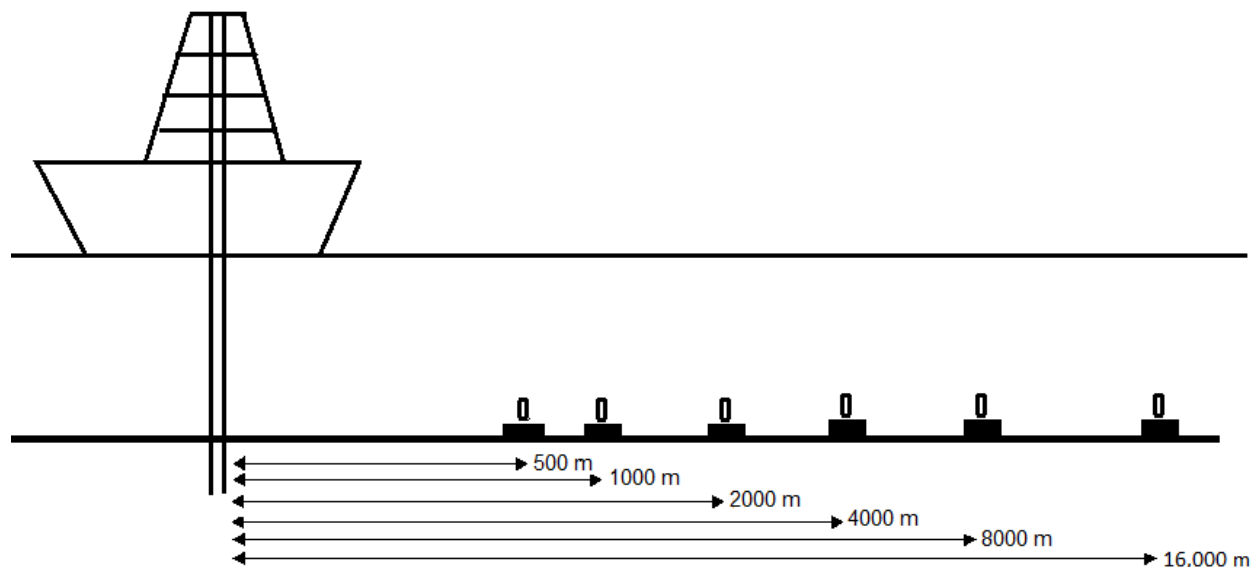


FIGURE 2 AMAR FOR ACOUSTIC MONITORING OF EXPLORATORY DRILLING ACTIVITIES

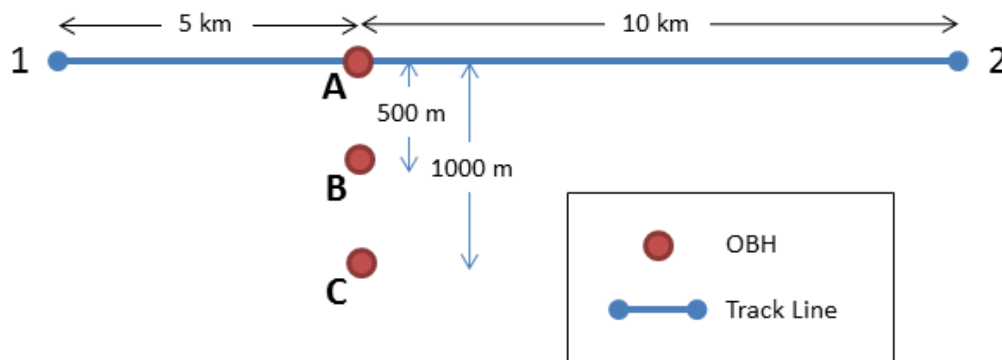


The deployment of drilling sound monitoring equipment will occur before, or as soon as possible after the *Discoverer* and the *Polar Pioneer* are on site. Activity logs of exploration drilling operations and nearby vessel activities will be maintained to correlate with these acoustic measurements. All results, including back-propagated source levels for each operation, will be reported in the 90-day report.

Vessel Sound Characterization

Vessel sound characterizations will be performed using dedicated recorders deployed at sufficient distances from exploration drilling operations so that sound produced by those activities does not interfere. Three AMARs will be deployed on and perpendicular to a sail track on which all Shell contracted vessels will transit. The deployment geometry will be as shown in Figure 3. This geometry is designed to obtain sound level measurements as a function of distance and direction. The fore and aft directions are sampled continuously over longer distances to 3 and 6 miles (5 and 10 km) respectively, while broadside and other directions are sampled as the vessels pass closer to the recorders.

FIGURE 3 AMAR DEPLOYMENT GEOMETRY RELATIVE TO VESSEL SAIL TRACK FOR SUPPORT VESSEL SOUND CHARACTERIZATION MEASUREMENTS



Vessel sound measurements will be processed and reported in a manner similar to that used by Shell and other operators in the Beaufort and Chukchi Seas during seismic survey operations. The measurements will further be analyzed to calculate source levels. Source directivity effects will be examined and reported. Those results will include sound level data but not source level calculations. All vessel characterization results, including source levels, will be reported in 1/3-octave bands in the project 90-day report.

Zero-Offset Vertical Seismic Profiling Sound Monitoring

Shell may conduct a geophysical survey referred to as a ZVSP, at two drill sites in 2015. During ZVSP surveys, an airgun array, which is much smaller than those used for routine seismic surveys, is deployed at a location near or adjacent to the drilling unit, while receivers are placed (temporarily anchored) in the wellbore. The sound source (airgun array) is fired repeatedly, and the reflected sonic waves are recorded by receivers (geophones) located in the wellbore. The geophones, typically a string of them, are then raised up to the next interval in the wellbore and the process is repeated until the entire wellbore has been surveyed. The purpose of the ZVSP survey is to gather geophysical information at various depths in the wellbore, which can then be used to tie-in or ground-truth geophysical information from the previously collected 2D and 3D seismic surveys with geological data collected within the wellbore.

Shell will conduct ZVSP surveys in which the sound source is maintained at a constant location near the wellbore. Two sound sources have been proposed by Shell for the ZVSP surveys in 2015. The first is a small airgun array that consists of three 150 in³ (2,458 cm³) airguns for a total volume of 450 in³ (7,374

cm³). The second ZVSP sound source consists of two 250 in³ (4,097 cm³) airguns with a total volume of 500 in³ (8,194 cm³). Specifications of the arrays are provided in Table 2. A representative depiction of the arrays to be used by Shell in 2015 is depicted within its frame or sled (Figure 4).

FIGURE 4 REPRESENTATIVE DEPICTION OF THE SOUND SOURCE TO BE USED FOR THE ZVSP SURVEYS DURING SHELL'S EXPLORATION DRILLING PROGRAM IN THE CHUKCHI SEA

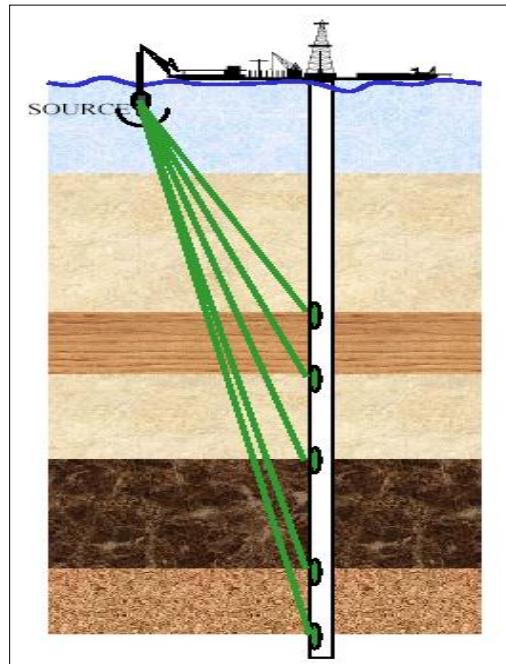


TABLE 2 SOUND SOURCE (AIRGUN ARRAY) SPECIFICATIONS FOR ZVSP SURVEYS IN THE CHUKCHI SEA

Source Type	No. Sources	Maximum Total Chamber Size	Pressure	Source Depth	Zero-Peak Sound Pressure Level
Sodera Triple G150	3 airguns: 3 X 150 in ³	450 in ³ (7,374 cm ³)	3,000 psi (207 bar)	7 m (23 ft.)	241 dB re 1 μPa @ 1m
Sodera Parallel G250	2 airguns: 2 X 250 in ³	500 in ³ (8,194 cm ³)	3,000 psi (207 bar)	7 m (23 ft.)	239 dB re 1 μPa @ 1m

A ZVSP survey is typically conducted at each well after total depth is reached but may be conducted at a shallower depth. For each survey, the sound source (airgun array) would be deployed over the side of the *Discoverer* or the *Polar Pioneer* with a crane. The sound source will be positioned 50-200ft (15-61 m) from the wellhead (depending on crane location), at a depth of ~10-23ft (3-7 m) below the water surface. Receivers will be temporarily anchored in the wellbore at depth (Figure 5). The sound source will be pressured up to 3,000 pounds per square inch (psi), and activated 5-7 times at approximately 20-second intervals. The receivers will then be moved to the next interval of the wellbore and re-anchored, after which the airgun array will again be activated 5-7 times. This process will be repeated until the entire wellbore has been surveyed in this manner. The interval between anchor points for the receiver array is usually 200-300 ft. (61-91 m). A typical ZVSP survey takes about 10-14 hours to complete per well (depending on the depth of the well and the number of anchoring points in each well).

FIGURE 5 A SCHEMATIC OF ZVSP OPERATIONS TO BE CONDUCTED DURING ZVSP SURVEYS DURING SHELL'S EXPLORATION DRILLING PROGRAM IN THE CHUKCHI SEA

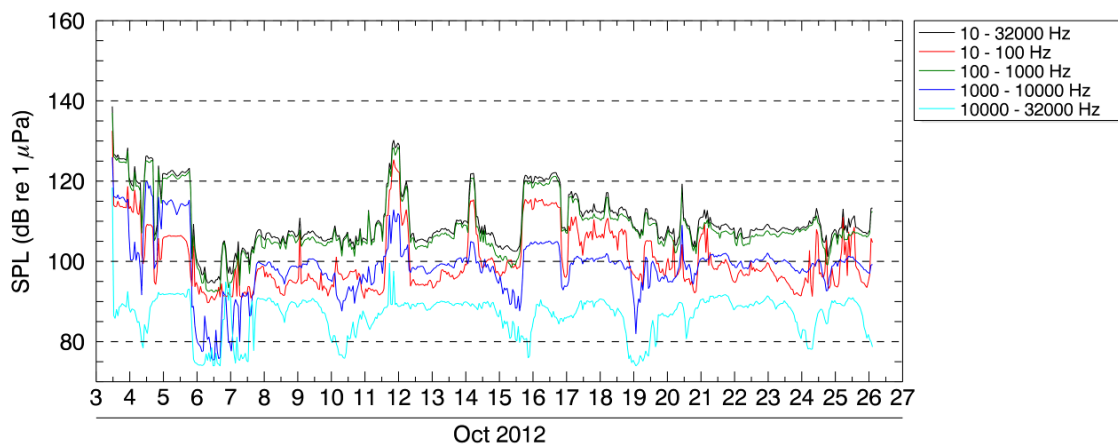


ZVSP sound verification measurements will be performed using either the AMARs that are deployed for drilling unit sound characterizations, or by JASCO Ocean Bottom Hydrophone (OBH) recorders. The use of AMARs or OBHs depends on specific timing. These measurements will be required by the NMFS; the AMARs will not be retrieved until several days after the ZVSP, as they are intended to monitor during retrievals of drilling unit anchors and related support activities. If the ZVSP acoustic measurements are required sooner, four OBH recorders would be deployed at the same locations and those could be retrieved immediately following the ZVSP measurement. The ZVSP measurements can be delivered within 120 hours of retrieval and download of the data from either instrument type.

Acoustic Data Analyses

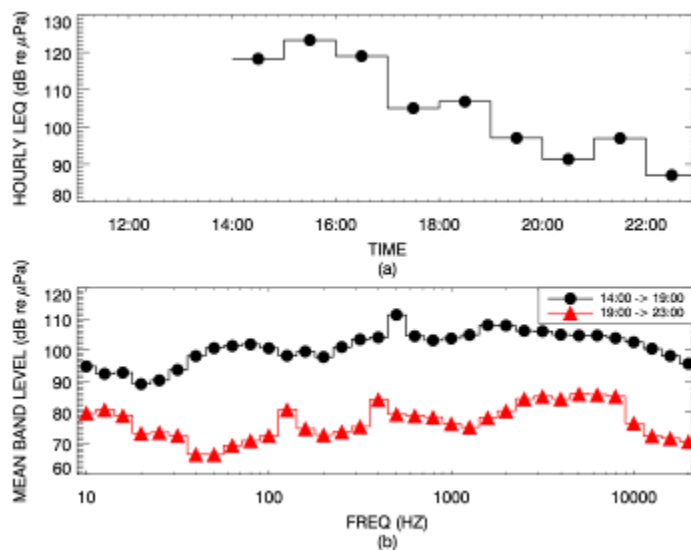
Exploration drilling sound data will be analyzed to extract a record of the frequency-dependent sound levels as a function of time. Figure 6 shows results of this type of analysis. These results are also useful for correlating measured sound energy events with specific survey operations. The analysis provides absolute sound levels in finite frequency bands that can be tailored to match the highest-sensitivity hearing ranges for species of interest. For example, bowhead hearing is thought to be most acute in the 100 Hz – 1,000 Hz frequency range that corresponds with the green line in the upper plot of Figure 6.

FIGURE 6 EXAMPLE RESULT DISPLAY SHOWING SOUND LEVEL SPECTRAL ENERGY DISTRIBUTION BETWEEN SEVERAL DIFFERENT FREQUENCY BANDS



The analyses will also consider sound level integrated through 1-hour durations (referred to as sound energy equivalent level [Leq] 1-hour). Figure 7 shows an example of a Leq analysis of hydrophone data. Similar graphs for long time periods will be generated as part of the data analysis performed for indicating drilling sound variation with time in selected frequency bands.

FIGURE 7 UPPER: 1-HOUR LEQ LEVELS THAT WILL BE CALCULATED FROM ACOUSTIC MEASUREMENTS FOR USE IN CORRELATING WITH POSSIBLE BOWHEAD WHALE DEFLECTION DATA. LOWER: FREQUENCY BAND DISTRIBUTION OF SOUND ENERGY IN TWO DIFFERENT TIME PERIODS



Reporting of Results

Acoustic sound level results will be reported in the 90-day and comprehensive reports for this program. The reports will include:

- sound source levels for the drilling units and all drilling support vessels;
- spectrogram and band level versus time plots computed from the continuous recordings obtained from the hydrophone systems;
- hourly Leq levels at the hydrophone locations; and
- correlation of exploration drilling source levels with the type of exploration drilling operation being performed. These results will be obtained by observing differences in drilling sound associated with differences in drilling unit activities as indicated in detailed drilling unit logs.

ACOUSTIC “NET” ARRAY IN CHUKCHI SEA

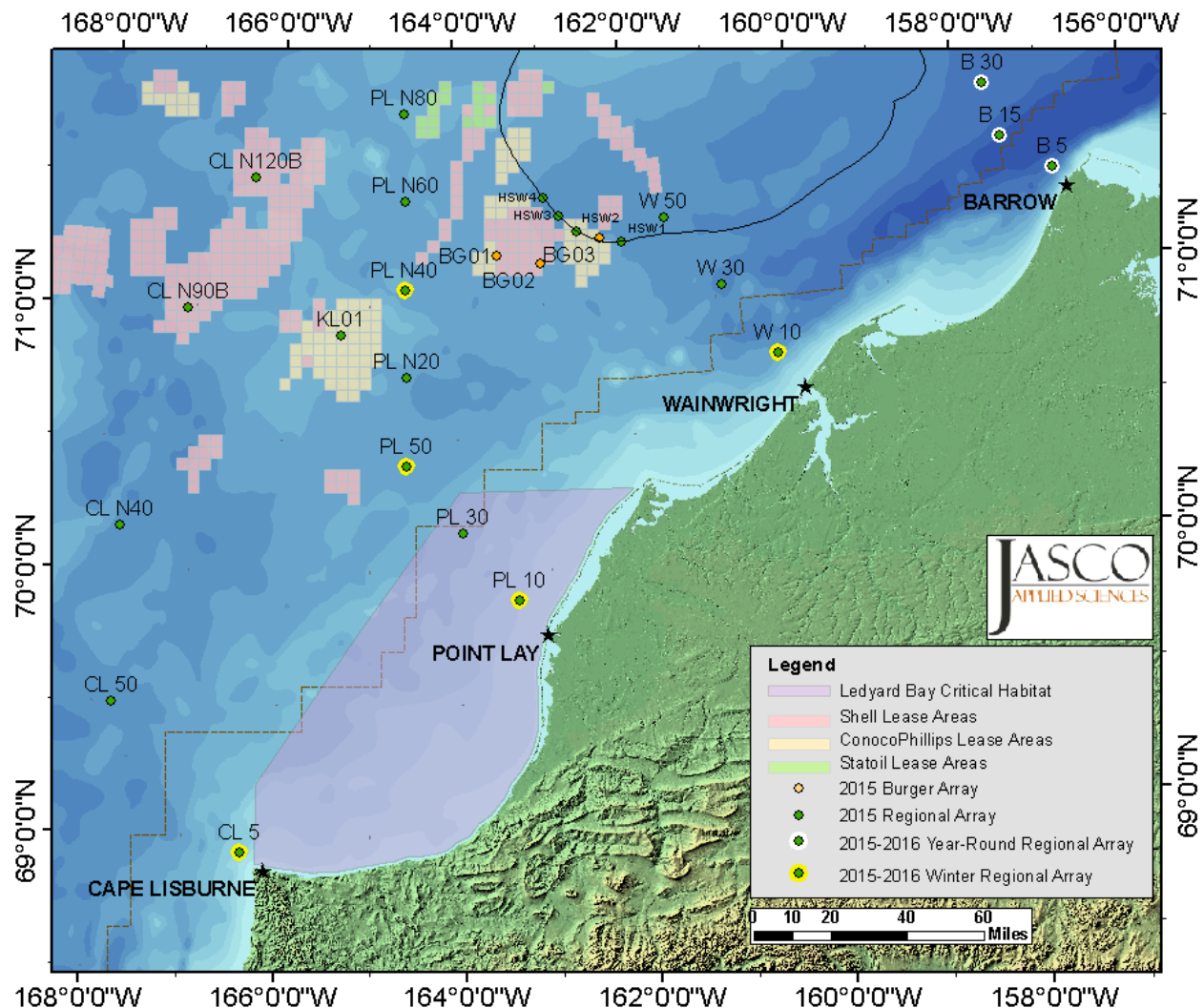
Background and Objectives

This section describes acoustic studies that were undertaken from 2006 through 2013 in the Chukchi Sea as part of the Joint Monitoring Program and that will be continued by Shell during exploration drilling activities. The acoustic “net” array used during the 2006–2013 field seasons in the Chukchi Sea was designed to accomplish two main objectives. The first was to collect information on the occurrence and distribution of marine mammals (including beluga whale, bowhead whale, walrus and other species) that may be available to subsistence hunters near villages along the Chukchi Sea coast and to document their relative abundance, habitat use, and migratory patterns. The second objective was to measure the ambient soundscape throughout the eastern Chukchi Sea and to record received levels of sounds from industry and other activities further offshore in the Chukchi Sea.

Technical Approach

A net array configuration similar to that deployed in 2007–2013 is again proposed. The basic components of this effort consist of autonomous acoustic recorders deployed widely across the U.S. Chukchi Sea during the open water season and then more limited arrays during the winter season. These calibrated systems sample at 16 kHz with 24-bit resolution, and are capable of recording marine mammal sounds and making anthropogenic noise measurements. The net array configuration will include a regional array of 23 AMARs deployed July–October off the four main transect locations: Cape Lisburne, Point Lay, Wainwright and Barrow as shown in Figure 8. The Wainwright line will not include recorder through the HSWUA as it has over the previous seven years, due to time-area restrictions on entering the HSWUA imposed by the USFWS. All of these offshore systems will capture sounds associated with exploration drilling, where present, over large distances to help characterize the sound transmission properties in the Chukchi Sea. Three additional summer AMARs will be deployed around the Burger drill sites to monitor directional variations and longer-range propagation of drilling-related sounds. These recorders will also be used to examine marine mammal vocalization patterns in vicinity of exploration drilling activities. The regional recorders will be retrieved in early October 2015; acoustic monitoring will continue through the winter with 5 AMARs deployed October 2015–August 2016 at the yellow-highlighted locations in Figure 8 and 3 year-round (August 2015–August 2016) recorders deployed off Barrow at the white-highlighted locations in Figure 8. The winter recorders will sample at 16 kHz on a 17% duty cycle (40 minutes every 4 hours). The winter recorders deployed in previous years have provided important information about fall and spring migrations of bowhead, beluga, walrus and several seal species.

FIGURE 8 PROPOSED OPEN WATER DEPLOYMENT LOCATIONS OF ACOUSTIC RECORDERS IN THE EASTERN CHUKCHI SEA, ALASKA



Analysis and Reporting

The Chukchi acoustic net array will produce an extremely large dataset comprising several Terabytes of acoustic data. The analyses of these data require identification of marine mammal vocalizations. Because of the very large amount of data to be processed, the analysis methods will incorporate automated vocalization detection algorithms that have been developed over several years. While the hydrophones used in the net array are not directional, and therefore not capable of accurate localization of detections, the number of vocalizations detected on each of the sensors provides a measure of the relative spatial distribution of some marine mammal species, assuming that vocalization patterns are consistent within a species across the spatial and geographic distribution of the hydrophone array. These results therefore provide information such as timing of migrations and routes of migration for belugas and bowheads.

A second purpose of the Chukchi net array is to monitor the amplitude of exploration drilling sound propagation over a very large area. It is expected that sounds from exploratory drilling activities will be detectable on hydrophone systems within approximately 30 km of the drilling units when ambient sound energy conditions are low. The drilling sound levels at recorder locations will be quantified and reported.

Analysis of all acoustic data will be prioritized to address the primary questions. The primary data analysis questions are to (a) determine when, where, and what species of animals are acoustically detected on each recorder (b) analyze data as a whole to determine offshore distributions as a function of time, (c) quantify spatial and temporal variability in the ambient sound energy, and (d) measure received levels of exploration drilling survey events and drilling unit activities. The detection data will be used to develop spatial and temporal animal detection distributions. Statistical analyses will be used to test for changes in animal detections and distributions as a function of different variables (e.g., time of day, season, environmental conditions, and ambient sound energy, and drilling or vessel sound levels).

CHUKCHI OFFSHORE AERIAL PHOTOGRAPHIC MONITORING PROGRAM

Shell has been reticent to conduct manned aerial surveys in the offshore Chukchi Sea because conducting those surveys puts people at risk. There is a strong desire; however, to obtain data on marine mammal distribution in the offshore Chukchi Sea and Shell will conduct an offshore aerial wildlife monitoring photographic survey that would put fewer people at risk as an alternative to the fully-manned aerial survey. The photographic survey would reduce the number of people on board the aircraft from six persons to two persons (the pilot and copilot) and would serve as a pilot study for future surveys that would use an Unmanned Aerial System (UAS) to capture the imagery. Successful aerial surveys with only pilots and camera systems were conducted over drilling locations in the Chukchi Sea in 2012.

Aerial photographic surveys have been used to monitor distribution and estimate densities of marine mammals in offshore areas since the mid-1980s, and before that, were used to estimate numbers of animals in large concentration areas. For example, Koski and Davis (1980), Koski et al. (2002) and Richard et al. (1990) used aerial photography to provide more precise estimates of numbers of belugas in concentration areas during aerial surveys of Lancaster Sound and Hudson Bay, respectively. Later Richard et al. (1994), Witting et al. (2005) and Heide-Jørgensen et al. (2010) used aerial photography to estimate numbers and densities of narwhals and minke whales in their survey areas.

Digital photographs provide many advantages over observations made by people if the imagery has sufficient resolution (Koski et al. 2013). With photographs there is constant detectability across the imagery, whereas observations by people decline with distance from the center line of the survey area. Observations at the outer limits of the transect can decline to 5-10% of the animals present for real-time observations by people during an aerial survey. The distance from the trackline of sightings is more accurately determined from photographs; group size can be more accurately determined; and sizes of animals can be measured, and hence much more accurately determined, in photographs. As a result of the latter capability, the presence or absence of a calf can be more accurately determined from a photograph than by in-the-moment visual observations. Another benefit of photographs over visual observations is that photographs can be reviewed by more than one independent observer allowing quantification of detection, identification and group size biases.

During the 2012 field season Shell successfully conducted photographic surveys using two Nikon D800 cameras obliquely mounted in a Twin Otter to record marine mammals around their drill sites in the Chukchi Sea. In addition, a HD video camera was tested and compared to the still camera for evaluation as a tool for real-time monitoring during future studies. Shell plans to use an Aero Commander aircraft, with similar Nikon cameras mounted in the airplane. If there is enough room, we will also mount a third vertically-mounted DSLR camera with a longer lens. The longer lens will give higher resolution imagery and will help us understand if we are missing seals and may allow us to identify many of the unidentified small pinnipeds detected during the 2012 study.

The proposed photographic survey will provide imagery that can be used to evaluate the ability of future studies to use the same image capturing systems in an UAS where people would not be put at risk. Although the two platforms are not the same, the slower airspeed and potentially lower flight altitude of

the UAS would mean that the data quality would be better from the UAS. Initial comparisons have been made between data collected by human observers on board both the Chukchi and Beaufort aerial survey aircraft and the digital imagery collected in 2012. Overall, the imagery provided better estimates of the number of large cetaceans and pinnipeds present but fewer sightings were identified to species in the imagery than by PSOs, because the PSOs had sightings in view for a longer period of time and could use behavior to differentiate species. The comparisons indicated that some cetaceans that were not seen by PSOs were detected in the imagery; errors in identification were made by the PSOs during the survey that could be resolved from examination of the imagery; cetaceans seen by PSOs were visible in the imagery; and during periods with large numbers of sightings, the imagery provided much better estimates of numbers of sightings and group size than the PSO data.

Camera Specifications

The cameras that we will use are Nikon D800s, or similar, which are 36.3 megapixel cameras that store imagery in 7,360×4,912 pixel arrays. The aircraft will be flown at 1,000 or 1,500 ft. above sea level and the cameras will be triggered to provide 50% overlap with adjacent photos and 100% overlap among all imagery. Actual trigger timing will depend on the survey speed and altitude of the aircraft but would be about every three (when at 1,000 ft.) or five seconds (when at 1,500 ft.). The cameras will have 21 mm f/2.8mm Zeiss lenses, which will each cover a swath ~720 or ~1000 m on the water surface with one pixel representing a 6–9 centimeters (cm) square at the water surface on the trackline and about 31 or 46 cm at the outer edge of the frame. Thus, the lenses are optimized for a 1,000 ft. flight altitude as this will provide higher resolution images. The cameras will be mounted such that one DSLR points 25° to the right and one 25° to the left side of the trackline, with the inner edge of both cameras' field of view overlapping about 67 or 100 m on either side of the centerline. These pixel sizes on the trackline are one seventeenth or one eighth of the pixel size (25 cm square) tested by Koski et al. (2009) during their tests with a video camera for detection of kayaks and is a smaller pixel size (better resolution) on the trackline than was tested by Amanda Hodgson (16.8 cm) during her surveys of humpback whales off Australia and which proved adequate for counting humpback whales in their imagery.

This camera configuration was used successfully in 2012 during surveys at both 1,000 and 1,500 ft. and the resolution permitted detection and identification of all medium and large cetaceans seen by PSOs on the manned aircraft. Further, it also permitted counting of walrus/bearded seals (Koski et al 2013) and some unknown fraction of small pinnipeds. The resolution does not always permit differentiation of bearded seals from walrus, especially when they are in the water. This imagery resolution provides slightly better ability for determining species and detecting animals than people would have in an aircraft flying at 1,000 ft. above sea level and more pinnipeds were sighted during the review of the imagery than PSOs saw in the same swath during the survey.

Route planning and data storage software are off-the-shelf products. The set up includes a harness to connect the camera and GPS to the Photo Coupler Controller which is connected to a GPS for triggering capture of images and recording of metadata for each image. The system can be powered by 10–32 volt DC or a custom power source and has a back-up battery power source to prevent interruption to data capture. Data will be stored on a memory card in the camera and camera settings will be set before the survey with shutter speed priority to ensure that motion blur is minimized. The system is “plug-and-play” and does not require input from persons on board the aircraft during the flight. The system can be pre-programmed to take photographs starting and stopping at predetermined times.

Survey Timing and Frequency

Offshore aerial wildlife monitoring photographic surveys would start as soon as the ice management, anchor handler and drilling units are at or near the first drill site and would continue throughout the drilling period and until the drilling related vessels have left the exploration drilling area. If in the event vessels enter the Chukchi Sea on or about 1 July, surveys would be initiated on or about 3 July or possibly sooner. This start date differs from past practices of beginning five days prior to initiation of an activity and continuing until five days after cessation of the activity because the presence of vessels with helidecks in the area where overflights will occur is one of the main mitigations that will allow for safe operation of the overflight program this far offshore. The surveys will be based out of Barrow and the same aircraft will conduct the offshore surveys around the drilling units and the coastal saw-tooth pattern.

Photographic surveys will be flown daily, weather permitting, throughout the drilling program. The offshore survey transects over the drilling area will be the default priority each day, as opposed to the nearshore/coastal pattern discussed below. The nearshore/coastal survey pattern will be flown only in instances when conditions offshore are not conducive for flying and coastal conditions would, however, support an overflight. There also may be isolated instances during the season when the near shore coastal survey would be identified as the priority due to a unique biological or operational scenario (e.g., walrus aggregations).

Survey Pattern

The aerial survey grids are designed to maximize coverage of the sound level fields of the drilling units during the different exploratory drilling activities. The survey grids can be modified as necessary based on weather and aircraft endurance. The transect lines are spaced 5 km apart in the center of the survey area to maximize the effort over the area where sound levels are expected to be highest and animal densities are likely to be lowest (Figure 9). The perimeter of the survey area is elliptical with a 50 km radius on the long axis of the ellipse (north-south orientation) and 40 km on the minor axis (east-west orientation). The two outer survey lines are spaced 10 km apart. Due to regulatory restrictions imposed by USFWS restricting flying at less than 1,500 feet over the HSWUA through September 30th, the entire survey pattern can only be flown if the flight altitude is 1,500 ft. or higher. Since the camera lenses are optimized for detecting wildlife from a 1,000 ft. flight altitude and a greater number of flights will likely be successful due to flying under low clouds, the survey area may be reduced to cover only the area where 1,000 ft. flight altitudes are permitted without restriction (Figure 10). The transect lines will be randomized for each survey by shifting all lines 0.1–2.5 km east or west. The total length of survey lines will be about 1,000 km and the exact length will depend on the location of the randomly selected start point.

FIGURE 9 AERIAL PHOTOGRAPHIC SURVEY TRANSECT LINES IN THE EASTERN CHUKCHI SEA. THE SURVEY GRID DESIGN IS BASED ON A 50 KM RADIUS ELLIPSE AND SURVEY EFFORT IS MOST INTENSIVE IN AREAS LIKELY TO HAVE HIGHER SOUND LEVELS. ALL LINES TO BE FLOW AT OR ABOVE 1,500 FT.

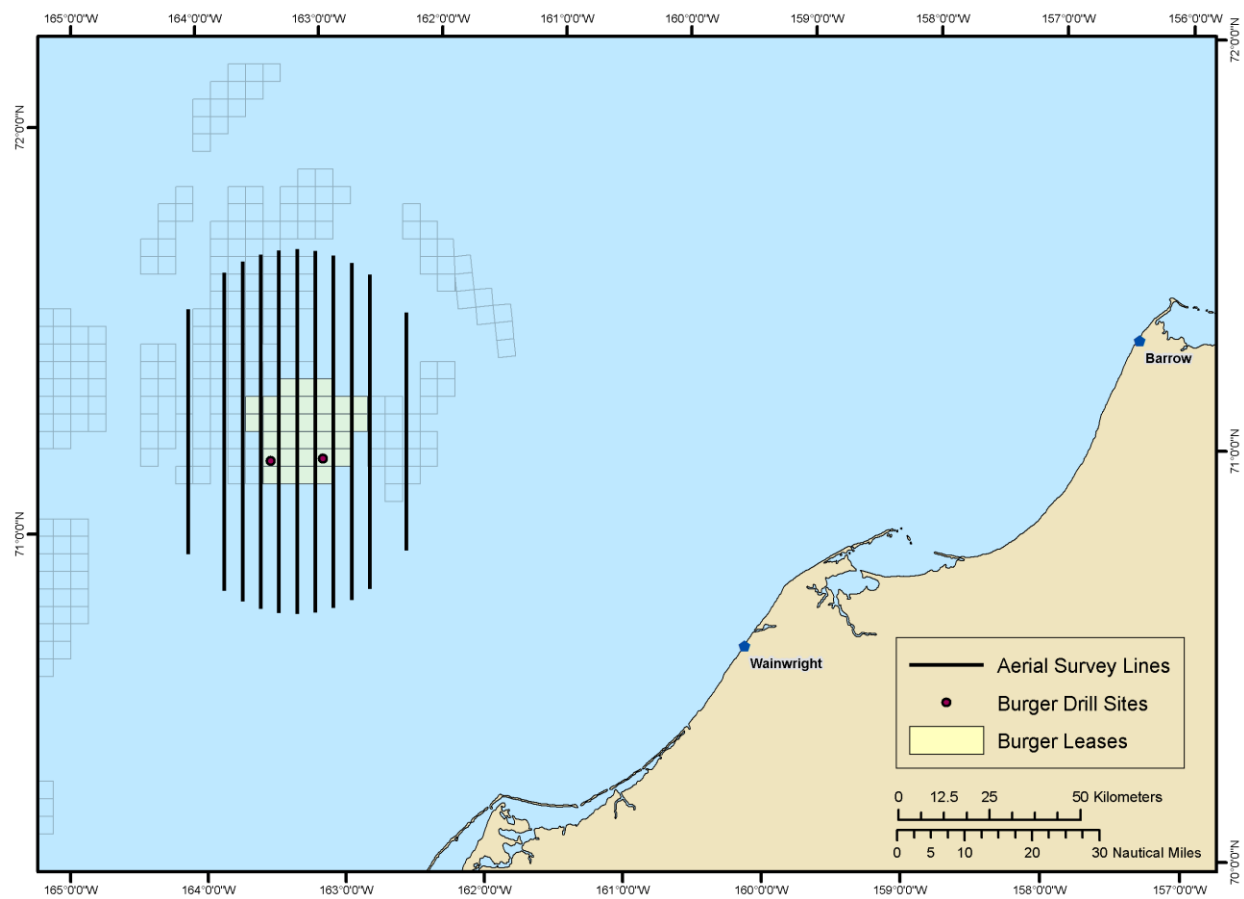
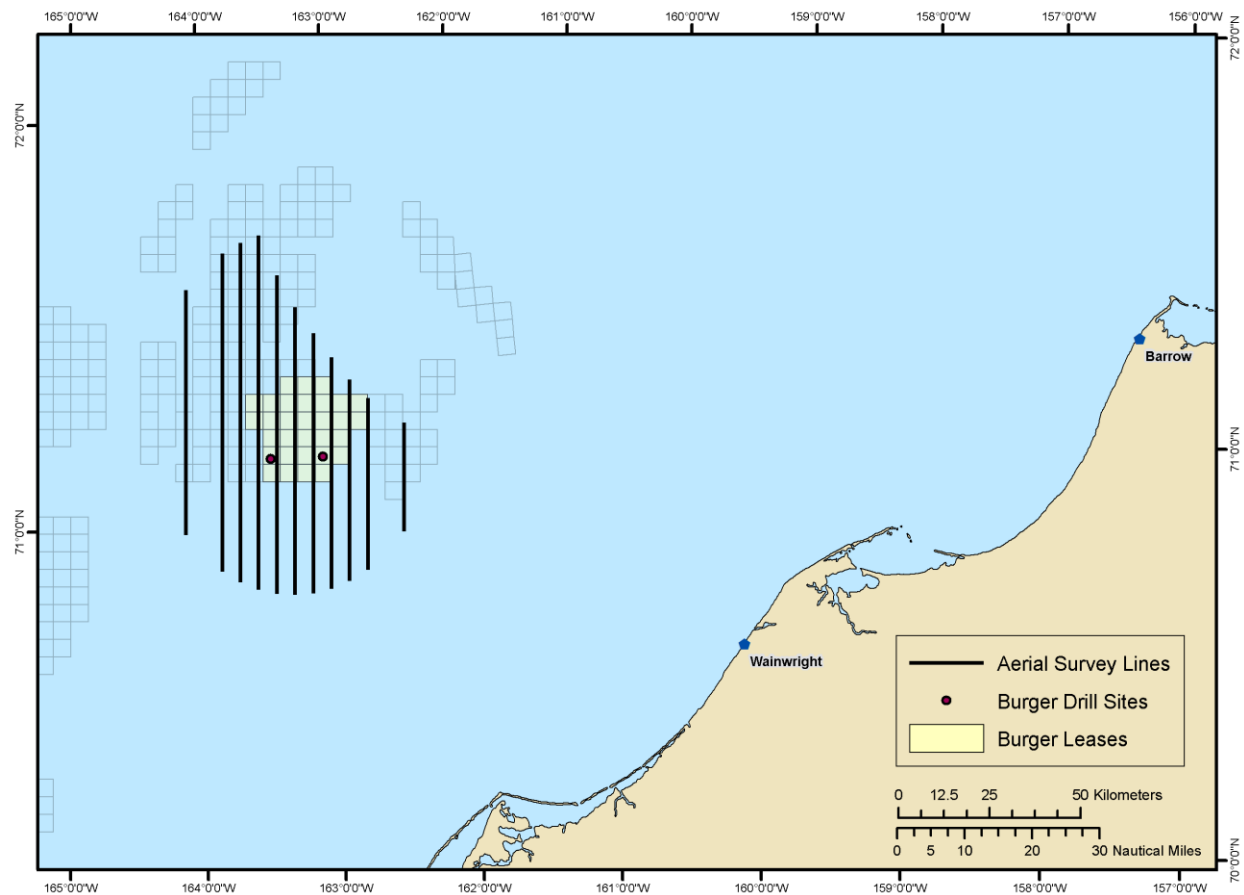


FIGURE 10 AERIAL PHOTOGRAPHIC SURVEY TRANSECT LINES IN THE EASTERN CHUKCHI SEA. THE SURVEY GRID DESIGN IS BASED ON A 50 KM RADIUS ELLIPSE AND SURVEY EFFORT IS MOST INTENSIVE IN AREAS LIKELY TO HAVE HIGHER SOUND LEVELS. ONLY LINES TO BE FLOWN AT 1,000 FT. ARE SHOWN.



Data Analyses

Following each survey, the imagery will be downloaded from the memory card to a portable hard drive and then backed up on a second hard drive and stored at accommodations in Barrow until the second hard drive can be transferred to Anchorage. In Anchorage, the imagery will be processed through a computer-assisted analysis program to identify where marine mammal sightings might be located among the many images obtained. A team of trained photo analysts will review the photographs identified as having potential sightings and record the appropriate data on each sighting. If time permits, a second review of some of the images will be conducted while in the field, but the sightings recorded during the second pass will be identified in the database as secondary sightings, so that biases associated with the detection in the imagery can be quantified. If time does not permit that review to be conducted while in the field, the review will be conducted by personnel in the office during or after the field season. A sample of images that are not identified by the computer-assisted analysis program will be examined in detail by the image analysts to determine if the program has missed marine mammal sightings. If the analysis program has missed mammal sightings, these data will be used to develop correction factors to account for these missed sightings among the images that were not examined.

Other Imagery and Sensors

In addition to the imagery indicated above, Shell is examining systems that are in development that would allow collection of additional imagery. They include collection of multi-spectral/hyperspectral imagery, infrared sensors, and a multi-camera system that would allow collection of imagery over a wider area. If these systems are ready for testing in 2015, Shell will consider incorporating these systems into the Chukchi Sea program.

CHUKCHI SEA COASTAL AERIAL SURVEY

Nearshore aerial surveys of marine mammals in the Chukchi Sea were conducted over coastal areas to approximately 23 miles (mi) (37 km) offshore in 2006–2008 and in 2010 in support of Shell's summer seismic exploration activities. In 2012, these surveys were flown when it was not possible to fly the photographic transects out over the Burger well site due to weather or rescue craft availability. These surveys provided data on the distribution and abundance of marine mammals in nearshore waters of the Chukchi Sea. Shell plans to conduct these nearshore aerial surveys in the Chukchi Sea as opportunities unfold and surveys will be similar to those conducted during previous years except that no PSOs will be onboard the aircraft. As noted above, the first priority will be to conduct photographic surveys around the offshore exploration drilling activities each day conditions allow, but nearshore surveys will be conducted whenever weather does not permit flying offshore. As in past years, surveys in the southern part of the nearshore survey area will depend on the end of the beluga hunt near Point Lay. In past years, Point Lay has requested that aerial surveys not be conducted until after the beluga hunt has ended and so the start of surveys has been delayed until mid-July.

Alaskan Natives from villages along the east coast of the Chukchi Sea hunt marine mammals during the summer and Native communities are concerned that offshore oil and gas exploration activities may negatively impact their ability to harvest marine mammals. Of particular concern are potential impacts on the beluga harvest at Point Lay and on future bowhead harvests at Point Hope, Point Lay, Wainwright and Barrow. Other species of concern in the Chukchi Sea include the gray whale; bearded, ringed, and spotted seals; and walrus. Gray whale and harbor porpoise are expected to be the most numerous cetacean species encountered during the proposed aerial survey; although harbor porpoise are abundant they are difficult to detect from aircraft because of their small size and brief surfacing. Beluga whales may occur in high numbers early in the season. The ringed seal is likely to be the most abundant of the pinniped species. The current aerial survey program will be designed to collect distribution data on cetaceans but will be limited in its ability to collect similar data on pinnipeds and harbor porpoises because they are not reliably detectable during review of the collected images unless a third camera with a 50 mm or similar lens is deployed.

Objectives

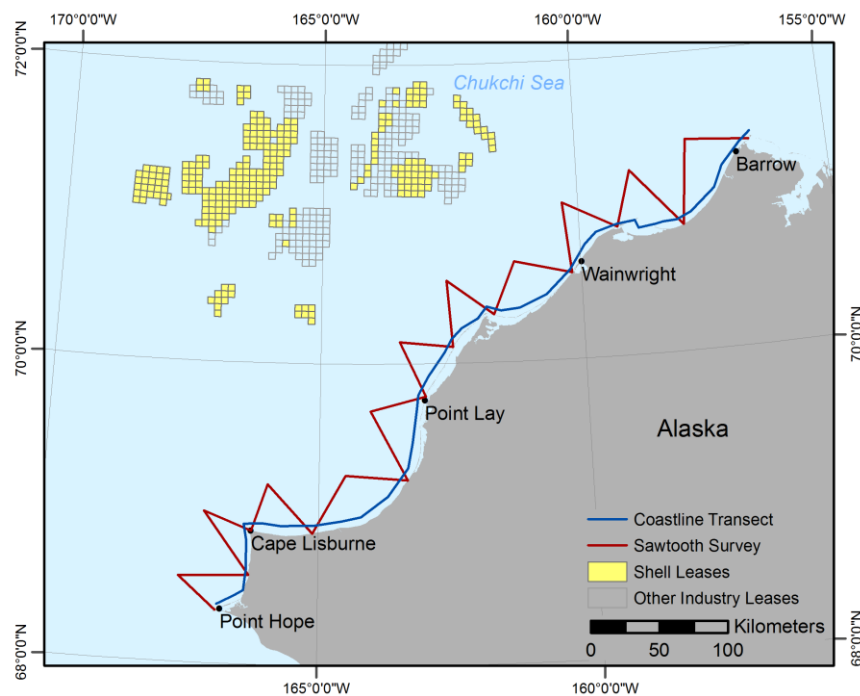
The aerial survey program objectives will be:

- to collect data on the distribution and abundance of marine mammals in coastal areas of the eastern Chukchi Sea;
- to collect and report data on the distribution, numbers, orientation and behavior of marine mammals, particularly beluga whales, near traditional hunting areas in the eastern Chukchi Sea; and
- to collect marine mammal sighting data using digital media.

Survey Procedures

Transects will be flown in a saw-toothed pattern between the shore and 23 mi (37 km) offshore as well as along the coast from Point Barrow to Point Hope (Figure 11). This design will permit completion of the survey in one to two days and will provide representative coverage of the nearshore region. Sawtooth transects were designed by placing transect start/end points every 34 mi (55 km) along the offshore boundary of this 23 mi (37 km) wide nearshore zone, and at midpoints between those points along the coast. The transect line start/end points will be shifted along both the coast and the offshore boundary for each survey based upon a randomized starting location, but overall survey distance will not vary substantially. The coastline transect will simply follow the coastline or barrier islands. As with past surveys of the Chukchi Sea coast, coordination with coastal villages to avoid disturbance of the beluga whale subsistence hunt will be extremely important. “No-fly” zones around coastal villages or other hunting areas established during communications with village representatives will be in place until the end of the hunting season.

FIGURE 11 AERIAL SURVEY TRANSECTS LOCATION AND GENERAL PATTERN FOR THE EASTERN CHUKCHI SEA. SPECIFIC TRANSECT START-/END-POINTS WILL BE ALTERED RANDOMLY FROM SURVEY TO SURVEY, AND HUNTING AREAS WILL BE AVOIDED WHEN HUNTING IS OCCURRING



Standard aerial survey procedures used in previous marine mammal projects (by Shell as well as by others) will be followed. This will facilitate comparisons and (as appropriate) pooling with other data, and will minimize controversy about the chosen survey procedures. The aircraft will be flown at 110–120 knots ground speed and usually at an altitude of 1,000 ft. (305 m). In accordance with anticipated stipulations in the USFWS MMPA authorization, survey aircraft will be flown at 1,500 ft. (457 m) over the LBCHU. Aerial surveys at an altitude of 1,000 ft. (305 m) do not provide much information about seals but are suitable for bowhead, beluga, and gray whales. The need for a 1,000+ ft. (305+ m) or 1,500+ ft. (454+ m) cloud ceiling will limit the dates and times when surveys can be flown. Selection of a higher altitude for surveys would result in a significant reduction in the number of days during which surveys would be possible, impairing the ability of the aerial program to meet its objectives.

The surveyed area will include waters where belugas are usually available to subsistence hunters. If large concentrations of belugas are encountered during the survey, the aircraft will climb to ~10,000 ft. (3,050 m) altitude to avoid disturbing the cetaceans. If cetaceans are in offshore areas, the aircraft will climb high enough to include all cetaceans within a single photograph; typically about 3,000 ft. (914 m) altitude. When in shallow water, belugas and other marine mammals are more sensitive to aircraft over flights and other forms of disturbance than when they are offshore (see Richardson et al. 1995 for a review). They frequently leave shallow estuaries when over flown at altitudes of 2,000–3,000 ft. (610-904 m); whereas they rarely react to aircraft at 1,500 ft. (457 m) when offshore in deeper water. Additionally, if large groups of other marine mammals are encountered on the surveys, such as the large aggregations of walrus seen in 2007 and 2010, Shell will attempt to photograph the animals and provide location information to interested stakeholders.

Coordination with Other Aerial Surveys

The BOEM, the NMFS, the USFWS, the North Slope Borough (NSB), or other organizations may also conduct aerial surveys in the Chukchi Sea during the exploration drilling season. Shell will consult with any groups or organizations conducting aerial surveys along the eastern Chukchi Sea coast regarding coordination during the exploration drilling season. The objectives will be:

- to ensure aircraft separation when both crews conduct surveys in the same general region;
- to coordinate the aerial survey projects in order to maximize consistency and minimize duplication; and
- to maximize consistency with previous years' efforts in so far as feasible.

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